Practice Problems

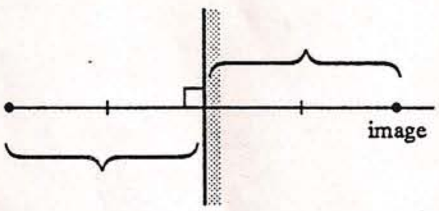
20. Suppose you are looking at a stamp through a magnifying glass and want to increase the size of the image. Should you move the glass closer to the stamp or farther away? Explain and indicate the maximum distance you should move it.

    From Figure (18–17), you can increase image size by making $(d_o - f)$ as small as possible. Thus, increase d_o until it is almost f, which is the limit.

Chapter Review Problems

pages 388–389

1. Find the image of the object in Figure 18–25.



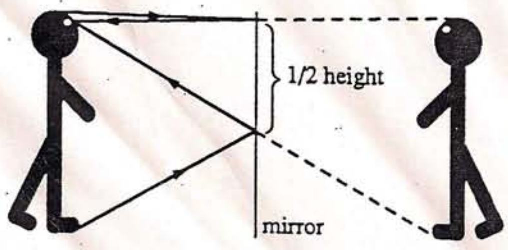
2. Penny wishes to take a picture of her image in a plane mirror. If the camera is 1.2 m in front of the mirror, at what distance should the camera lens be focused?

    The image is 1.2 m behind the mirror, so the camera lens should be set to 2.4 m.

3. Draw a ray diagram of a plane mirror to show that if you want to see yourself from your feet to the top of your head, the mirror must be at least half your height.

    The ray from top of head hits mirror halfway between eyes and top of head. Ray from feet hits mirror halfway between eyes and feet. Distance between the point the two rays hit the mirror is half the total height.

Chapter Review Problems



4. A concave mirror has a focal length of 10.0 cm. What is its radius of curvature?

    $c = 2f = 2(10.0\text{ cm}) = 20.0\text{ cm}$

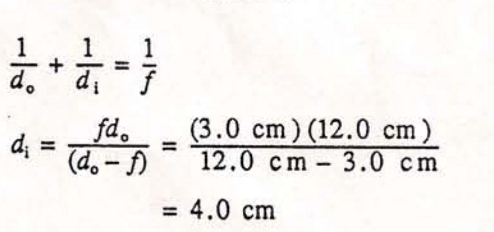
5. Light from a distant star is collected by a concave mirror. How far from the mirror is the image of the star if the radius of curvature is 150 cm?

    Stars are far enough away that the light coming into the mirror can be considered to be parallel and parallel light will converge at the focal point. Since $c = 2f$, $f = \frac{c}{2} = \frac{150\text{ cm}}{2} = 75.0$ cm

6. The sun falls on a concave mirror and forms an image 3.0 cm from the mirror. If an object 24 mm high is placed 12.0 cm from the mirror, where will its image be formed?

    The focal length of the mirror is 3.0 cm since that is the location of the image of the sun.

    a. Use a ray diagram.



    b. Use the mirror equation.

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

$$d_i = \frac{fd_o}{(d_o - f)} = \frac{(3.0\text{ cm})(12.0\text{ cm})}{12.0\text{ cm} - 3.0\text{ cm}}$$

$$= 4.0\text{ cm}$$

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c. How high is the image?

$$m = \frac{-d_i}{d_o} = \frac{-4.0\text{ cm}}{12.0\text{ cm}} = -0.33$$

$$h_i = mh_o = (-0.33)(24\text{ mm}) = -8.0\text{ mm}$$

7. An object is 30.0 cm from a concave mirror of 15-cm focal length. The object is 1.8 cm high.

a. Locate the image, using the mirror equation.

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

$$d_i = \frac{d_o f}{(d_o - f)} = \frac{(30.0\text{ cm})(15\text{ cm})}{30.0\text{ cm} - 15\text{ cm}}$$

$$= 30\text{ cm}$$

b. How high is the image?

$$\frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

$$h_i = \frac{-d_i h_o}{d_o} = \frac{-(30\text{ cm})(1.8\text{ cm})}{30.0\text{ cm}}$$

$$= -1.8\text{ cm}$$

8. A jeweler inspects a watch, with a diameter of 3.0 cm, by placing it 8.0 cm in front of a concave mirror of 12.0-cm focal length.

a. Where will the image of the watch appear?

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

$$d_i = \frac{d_o f}{(d_o - f)} = \frac{(8.0\text{ cm})(12\text{ cm})}{8.0\text{ cm} - 12.0\text{ cm}}$$

$$= -24\text{ cm}$$

b. What is the diameter of the image?

$$\frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

$$h_i = \frac{-d_i h_o}{d_o} = \frac{-(-24\text{ cm})(3.0\text{ cm})}{8.0\text{ cm}}$$

$$= +9.0\text{ cm}$$

9. A dentist uses a small mirror of radius 40 mm to locate a cavity in a patient's tooth. If the mirror is concave and held 16 mm from the tooth, what is its magnification of the resulting image?

$$f = \frac{c}{2} = \frac{40\text{ mm}}{2} = 20\text{ mm}$$

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

$$d_i = \frac{d_o f}{(d_o - f)} = \frac{(16\text{ mm})(20\text{ mm})}{16\text{ mm} - 20\text{ mm}}$$

$$= -80\text{ mm}$$

$$m = \frac{-d_i}{d_o} = \frac{-(-80\text{ mm})}{16\text{ mm}} = 5.0$$

10. A production line inspector wants a mirror that produces an upright image with magnification 7.5 when it is located 14.0 mm from a machine part.

a. What kind of mirror would do this job?

An enlarged, upright image only results from a concave mirror, with object inside of the focal length.

b. What is its radius of curvature?

$m = \frac{-d_i}{d_o}$, so

$$d_i = -md_o = -(7.5)(14.0\text{ mm})$$
$$= -105\text{ mm}$$

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

$$f = \frac{d_o d_i}{(d_i - d_o)} = \frac{(14.0\text{ mm})(-105\text{ mm})}{14.0\text{ mm} - 105\text{ mm}}$$

$$= 16.2\text{ mm}$$

radius of curvature $= 2f = (2)(16.2\text{ mm})$
$= 32.4\text{ mm}$

11. Shiny lawn spheres placed on pedestals are convex mirrors. One such sphere has a diameter of 40 cm. A 12-cm robin sits in a tree 1.5 m from the sphere.

a. Where is the image of the robin?

$r = 20$ cm, $f = -10$ cm

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

$$d_i = \frac{fd_o}{(d_o - f)} = \frac{(-10.0\text{ cm})(1.5\text{ m})}{1.5\text{ m} - (-10.0\text{ cm})}$$

$$= -9.4\text{ cm}$$

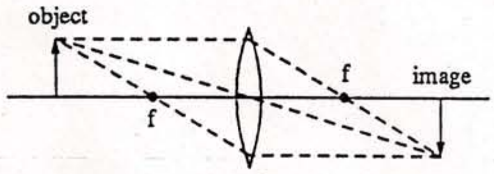
b. How long is the robin's image?

$$m = \frac{h_i}{h_o} = \frac{-d_i}{d_o} = \frac{-(-9.4\text{ cm})}{150\text{ cm}}$$

$$= +0.063$$

$$h_i = mh_o = (0.063)(12\text{ cm}) = 0.75\text{ cm}$$

12. The focal length of a convex lens is 17 cm. A candle is placed 34 cm in front of the lens. Make a ray diagram to find the location of the image.



13. The convex lens of a copy machine has a focal length of 25.0 cm. A letter to be copied is placed 40.0 cm from the lens.

a. How far from the lens is the copy paper located?

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

$$d_i = \frac{d_o f}{(d_o - f)} = \frac{(40.0\text{ cm})(25.0\text{ cm})}{40.0\text{ cm} - 25.0\text{ cm}}$$

$$= 66.7\text{ cm}$$

b. The machine was adjusted to give an enlarged copy of the letter. How much larger will the copy be?

$$\frac{h_i}{h_o} = \frac{d_i}{d_o}$$

$$h_i = \frac{d_i h_o}{d_o} = \frac{(66.7\text{ cm})(h_o)}{40.0\text{ cm}} = 1.67\ h_o$$

Chapter Review Problems

14. Camera lenses are described in terms of their focal length. A 50.0 mm lens has a focal length of 50.0 mm.

a. A camera is focused on an object 3.0 m away using a 50.0 mm lens. Locate the position of the image.

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

$$d_i = \frac{d_o f}{(d_o - f)} = \frac{(3.0 \times 10^3\text{ mm})(50.0\text{ mm})}{3.0 \times 10^3\text{ mm} - 50.0\text{ mm}}$$

$$= 51\text{ mm}$$

b. A 1.00×10^3 mm lens is focused on an object 125 m away. Locate the position of the image.

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

$$d_i = \frac{d_o f}{(d_o - f)} = \frac{(125\text{ m})(1.00\text{ m})}{125\text{ m} - 1.00\text{ m}}$$

$$= 1.01\text{ m}$$

$$= 1.01 \times 10^3\text{ mm}$$

15. Solve Problem 10 using a lens rather than a mirror.

An enlarged, upright image requires a convex lens with the object inside the focal length.

$$m = \frac{-d_i}{d_o}$$

$$d_i = -md_o = -(7.5)(14.0\text{ mm}) = -105\text{ mm}$$

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

$$f = \frac{d_o d_i}{(d_i + d_o)} = \frac{(14.0\text{ mm})(-105\text{ mm})}{14.0\text{ mm} - 105\text{ mm}}$$

$$= 16.2\text{ mm}$$

16. A convex lens is needed to produce an image located 24 cm behind the lens that is 0.75 the size of the object. What focal length should be specified?

$$d_i = 0.75 d_o,\text{ so } d_o = \frac{d_i}{0.75} = \frac{24\text{ cm}}{0.75} = 32\text{ cm}$$

$$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o},\text{ so}$$

$$f = \frac{d_o d_i}{d_o + d_i} = \frac{(32\text{ cm})(24\text{ cm})}{32\text{ cm} + 24\text{ cm}} = 14\text{ cm}$$

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Chapter Review Problems

17. A microscope slide with an onion cell is placed 12 mm from the objective lens of a microscope. The focal length of the objective lens is 10.0 mm.

a. How far from the lens is the image formed?

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

$$d_i = \frac{d_o f}{(d_o - f)} = \frac{(12.0 \text{ mm})(10.0 \text{ mm})}{12.0 \text{ mm} - 10.0 \text{ mm}}$$

$$= 60.0 \text{ mm}$$

b. What is the magnification of this image?

$$m_o = \frac{-d_i}{d_o} = \frac{-60.0 \text{ mm}}{12.0 \text{ mm}} = -5.0$$

c. The real image formed is located 10.0 mm beneath the eyepiece lens of the microscope. If the focal length of the eyepiece is 20.0 mm, where does the final image appear?

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

$$d_i = \frac{d_o f}{(d_o - f)} = \frac{(10.0 \text{ mm})(20.0 \text{ mm})}{10.0 \text{ mm} - 20.0 \text{ mm}}$$

$$= -20.0 \text{ mm}$$

d. What is the final magnification of this compound system?

$$m_e = \frac{-d_i}{d_o} = \frac{-(-20.0 \text{ mm})}{10.0 \text{ mm}} = 2.00$$

$$m_{total} = (m_o)(m_e) = (-5.0)(2.00) = -10.0$$

18. In order to clearly read a book at 25 cm away, a farsighted person needs an image distance of -45 cm. What focal length is needed?

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}, \text{ so}$$

$$f = \frac{d_o d_i}{(d_o - d_i)} = \frac{(25 \text{ cm})(-45 \text{ cm})}{25 \text{ cm} + (-45 \text{ cm})}$$

$$= 56 \text{ cm}$$

Supplemental Problems (Appendix B)

1. Sally's face is 75 cm in front of a plane mirror. Where is the image of Sally's face?

75 cm behind the mirror

2. A concave mirror has a focal length of 10.0 cm. What is its radius of curvature?

$$r = 2f = 2(10.0 \text{ cm}) = 20.0 \text{ cm}$$

3. Light from a distant star is collected by a concave mirror that has a radius of curvature of 150 cm. How far from the mirror is the image of the star?

$$f = \frac{r}{2} = \frac{150 \text{ cm}}{2} = 75.0 \text{ cm}$$

$$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o}, \text{ but } d_o \text{ is extremely large, so}$$

$$\frac{1}{f} = \frac{1}{d_i}, \text{ or } d_i f = 75.0 \text{ cm}$$

4. An object is placed 25.0 cm away from a concave mirror that has a focal length of 5.00 cm. Where is the image located?

$$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o}, \text{ so}$$

$$d_i = \frac{d_o f}{(d_o - f)} = \frac{(25.0 \text{ cm})(5.00 \text{ cm})}{(25.0 \text{ cm} - 5.00 \text{ cm})}$$

$$= 6.25 \text{ cm, or}$$

6.25 cm in front of the mirror

5. An object and its image as seen in a concave mirror are the same height when the object is 48.4 cm from the mirror. What is the focal length of the mirror?

For a concave mirror, an object and its image have the same height when the object is two focal lengths from the mirror. Therefore, 48.4 cm = $2f$, or f = 48.4 cm/2 = 24.2 cm

6. An object placed 50.0 cm from a concave mirror gives a real image 33.3 cm from the mirror. If the image is 28.4 cm high, what is the height of the object?

$$m = \frac{h_i}{h_o} = \frac{-d_i}{d_o} = \frac{-33.3 \text{ cm}}{50.0 \text{ cm}} = -0.666, \text{ so}$$

$$h_o = \frac{h_i}{m} = \frac{-28.4 \text{ cm}}{(-0.666)} = 42.6 \text{ cm}$$

m is negative, so the image is inverted and h_i is negative.

8. White light falls on a single slit 0.050 mm wide. A screen is placed 1.00 m away. A student first puts a blue–violet filter (λ = 441 nm) over the slit, then a red filter (λ = 622 nm). The student measures the width of the central peak, that is, the distance between the two dark bands.

a. Will the band be wider with the blue or the red filter?

Red, because central peak width is proportional to wavelength.

b. Find the width for the two filters.

Width $= 2x = 2\lambda L/w$.

For blue,

$$2x = \frac{2(4.41 \times 10^{-7}\ \text{m})(1.00\ \text{m})}{(5.0 \times 10^{-5}\ \text{m})}$$

$= 18$ mm

For red,

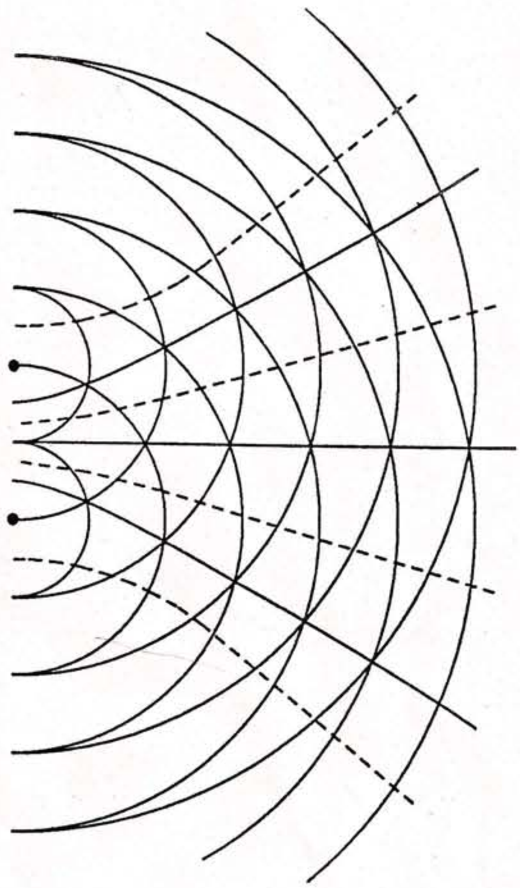
$$2x = \frac{2(6.22 \times 10^{-7}\ \text{m})(1.00\ \text{m})}{(5.0 \times 10^{-5}\ \text{m})}$$

$= 25$ mm.

Chapter Review Problems

pages 404–405

1. Using a compass and ruler, construct a scale diagram of the interference pattern that results when waves 1 cm in length fall on two slits 2 cm apart. The slits may be represented by two dots spaced 2 cm apart and kept to one side of the paper. Draw a line through all lines of reinforcement. Draw dotted lines through all nodal lines.



2. A radio station uses two antennas and broadcasts at 600 kHz. Radio waves travel at the speed of light. The waves from the two antennas are kept in step.

a. What is the wavelength of the signals emitted by the station?

$v = f\lambda$, so

$$\lambda = \frac{v}{f} = \frac{(3.00 \times 10^{8}\ \text{m/s})}{(600 \times 10^{3}\ \text{Hz})} = 500\ \text{m}$$

b. The occupants of a home that is located 17 500 m from one antenna and 19 500 m from the other antenna have their receiver tuned to the station. Is the reception good or poor? Explain?

The path difference is
19 500 m − 17 500 m = 2000 m.
The reception should be good since it is a multiple of the wavelength, and constructive interference will take place.

Chapter Review Problems

3. Light falls on a pair of slits 1.90×10^{-3} cm apart. The slits are 80.0 cm from the screen. The first–order bright line is 1.90 cm from the central bright line. What is the wavelength of the light?

$$\lambda = \frac{xd}{L} = \frac{(1.90 \text{ cm})(1.90 \times 10^{-3} \text{ cm})}{80.0 \text{ cm}}$$

$$= 4.51 \times 10^{-5} \text{ cm} = 451 \text{ nm}$$

4. Light of wavelength 542 nm falls on a double slit. First–order bright bands appear 4.00 cm from the central bright line. The screen is 1.20 m from the slits. How far apart are the slits?

$$\lambda = \frac{xd}{L}, \text{ so}$$

$$d = \frac{\lambda L}{x} = \frac{(5.42 \times 10^{-7} \text{ m})(1.20 \text{ m})}{4.00 \times 10^{-2} \text{ m}}$$

$$= 1.63 \times 10^{-5} \text{ m}$$

5. A lecturer is demonstrating two–slit interference with sound waves. Two speakers are used, 4.0 m apart. The sound frequency is 325 Hz. (The speed of sound is 343 m/s.) Students sit in seats 4.5 m away. What is the spacing between the locations where no sound is heard because of destructive interference?

$$v = f\lambda, \text{ so}$$

$$\lambda = \frac{v}{f} = \frac{343 \text{ m/s}}{325 \text{ Hz}} = 1.06 \text{ m}$$

$$x = \frac{\lambda L}{d} = \frac{(1.06 \text{ m})(4.5 \text{ m})}{4.0 \text{ m}} = 1.2 \text{ m}$$

6. Monochromatic light passes through a single slit with a width of 0.010 cm and falls on a screen 100 cm away. If the distance from the center of the pattern to the first band is 0.60 cm, what is the wavelength of the light?

$$y = \frac{\lambda L}{w}, \text{ so}$$

$$\lambda = \frac{yw}{L} = \frac{(0.60 \text{ cm})(0.010 \text{ cm})}{100 \text{ cm}}$$

$$= 6.00 \times 10^{-5} \text{ cm}$$

7. Light with a wavelength of 4.5×10^{-5} cm passes through a single slit and falls on a screen 100 cm away. If the slit is 0.015 cm wide, what is the distance from the center of the pattern to the first dark band?

$$y = \frac{\lambda L}{w} = \frac{(4.5 \times 10^{-5} \text{ cm})(100 \text{ cm})}{0.015 \text{ cm}} = 0.30 \text{ cm}$$

8. Monochromatic light with a wavelength of 400 nm passes through a single slit and falls on a screen 90 cm away. If the distance of the first–order dark band is 0.30 cm from the center of the pattern, what is the width of the slit?

$$y = \frac{\lambda L}{w}, \text{ so}$$

$$w = \frac{\lambda L}{y} = \frac{(4.00 \times 10^{-5} \text{ cm})(90 \text{ cm})}{0.30 \text{ cm}}$$

$$= 1.2 \times 10^{-2} \text{ cm}$$

9. Sound waves of frequency 550 Hz enter a window 1.2 m wide. The window is in the exact center of one wall of a theater 24 m × 12 m. The window is 12 m from the opposite wall, along which is a row of seats occupied by people. The theater is acoustically prepared to prevent the reflection of sound waves, and the speed of sound is 330 m/s. Two people in the row along the wall hear no sound. Where are they sitting?

$$v = f\lambda, \text{ so}$$

$$\lambda = \frac{v}{f} = \frac{330 \text{ m/s}}{550 \text{ Hz}} = 0.60 \text{ m}$$

$$y = \frac{\lambda L}{w} = \frac{(0.60 \text{ m})(12 \text{ m})}{1.2 \text{ m}} = 6.0 \text{ m}$$ to either side of center of the wall

10. A good diffraction grating has 2.50×10^{3} lines/cm. What is the distance between two lines in the grating?

$d = 1/(2.50 \times 10^{3} \text{ lines/cm})$
$= 4.00 \times 10^{-4}$ cm

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11. Using a grating with spacing of 4.00×10^{-4} cm, a red line appears 16.5 cm from the central line on a screen. The screen is 1.00 m from the grating. What is the wavelength of the red light?

$$\lambda = \frac{xd}{L} = \frac{(16.5\text{ cm})(4.00 \times 10^{-4}\text{ cm})}{100\text{ cm}}$$

$$= 6.60 \times 10^{-5}\text{ cm} = 660\text{ nm}$$

12. A spectrometer uses a grating with 12 000 lines/cm. Find the angles at which red light 632 nm and blue light 421 nm have the first-order bright bands.

$$d = \frac{1}{12\,000\text{ lines/cm}} = 8.33 \times 10^{-5}\text{ cm}$$

$$\lambda = d \sin\theta,\text{ so } \sin\theta = \frac{\lambda}{d}$$

For red light,

$$\sin\theta = \frac{6.32 \times 10^{-5}\text{ cm}}{8.33 \times 10^{-5}\text{ cm}} = 0.759,\text{ so } \theta = 49.4°$$

For blue light,

$$\sin\theta = \frac{4.21 \times 10^{-5}\text{ cm}}{8.33 \times 10^{-5}\text{ cm}} = 0.505,\text{ so } \theta = 30.4°$$

13. The ridges in the *Morpho* butterfly wing in the chapter opening photograph are spaced about 2.2×10^{-7} m apart. Explain how they could cause the wing to appear iridescent blue.

The ridges act as a diffraction grating. Any blue light of wavelength approximately 4.40×10^{-7} m is reflected strongly from this grating.

Chapter Review Problems

14. Janet uses a 33–1/3 rpm record as a diffraction grating. She shines a laser, $\lambda = 632.8$ nm, on the grating. On a screen 4.0 m from the record, a series of red dots 21 mm apart are seen.

a. How many ridges are there in a centimeter on the record?

$$\lambda = \frac{xd}{L},\text{ so}$$

$$d = \frac{\lambda L}{x} = \frac{(6.328 \times 10^{-7}\text{ m})(4.0\text{ m})}{0.021\text{ m}}$$

$$= 1.2 \times 10^{-4}\text{ m} = 1.2 \times 10^{-2}\text{ cm}$$

$$\frac{1}{d} = \frac{1}{1.2 \times 10^{-2}\text{ cm}} = 83\text{ ridges/cm}$$

b. She checks her results by noting that the ridges came from a song that lasted 4.01 minutes and took up 16 mm on the record. How many ridges should there be in a centimeter?

Number of ridges is
(4.01 min)(33.333 rev/min) = 134 ridges.
(134 ridges)/(1.6 cm) = 84 ridges/cm.

15. A camera with a 50 mm lens set at *f*/8 aperture has an opening 6.25 mm in diameter. Suppose this lens acts like a slit 6.25 mm wide. For light with $\lambda = 550$ nm, what is the resolution of the lens, the distance from the middle of the central bright band to the first-order dark band? The film is 50 mm from the lens.

$$y = \frac{\lambda L}{w} = \frac{(5.5 \times 10^{-4}\text{ mm})(50\text{ mm})}{6.25\text{ mm}}$$

$$= 4.4 \times 10^{-3}\text{ mm}$$

16. The owner of the camera in the previous problem tries to decide which film to buy for it. The expensive one, called fine-grain film, has 200 grains/mm. The less costly coarse-grain film has only 50 grains/mm. If the owner wants a grain to be no smaller than the width of the central bright band calculated above, which film should be purchased?

Band width is 4.4×10^{-3} mm.
Coarse grains are 1/50 mm = 2.0×10^{-2} mm, fine grains are 1/2000 mm = 5×10^{-3} mm.
Coarse grain is good enough.

17. Suppose the Hubble Space Telescope, 2.4 m in diameter, is in orbit 100 km above Earth and is turned to look at Earth. If you ignore the effect of the atmosphere, what is the resolution of this telescope? Use $\lambda = 500$ nm.

$$y = \frac{\lambda L}{w} = \frac{(5.00 \times 10^{-7}\ \text{m})(100\ 000\ \text{m})}{2.4\ \text{m}}$$

$$= 2.1 \times 10^{-2}\ \text{m} = 2.1\ \text{cm}$$

18. The image formed on the retina of the eye shows the effect of diffraction. The diameter of the iris opening in bright light is 3.0 mm. For green light, 545 nm wavelength, find the resolution of the eye. That is, find the distance from the center of the central band to the dark band. Assume the distance from iris to retina is 2.5 cm.

$$y = \frac{\lambda L}{w} = \frac{(5.45 \times 10^{-5}\ \text{cm})(2.5\ \text{cm})}{0.30\ \text{cm}}$$

$$= 4.5 \times 10^{-4}\ \text{cm}$$

19. Cone cells in the retina are about 1.5 μm apart. On how many cone cells does the image found in the previous problem fall? Would the eye's resolution be better if the iris were much larger, like the 10 mm diameter of the eagle's eye? Explain.

$(4.6 \times 10^{-6}\ \text{m})/(1.5 \times 10^{-6}\ \text{m/cell}) = 3$ cells. You need about 3 cells to tell light and dark edges. It would do no good to increase the resolution of the eye by using a larger iris because resolution is limited by cone separation in the retina.

Supplemental Problems (Appendix B)

1. Monochromatic light passes through two slits that are 0.0300 cm apart and it falls on a screen 120 cm away. The first-order image is 0.160 cm from the middle of the center band. What is the wavelength of the light used?

$\lambda = xd/L$
$= (1.60 \times 10^{-3}\ \text{m})(3.00 \times 10^{-4}\ \text{m})/(1.20\ \text{m})$
$= 4.00 \times 10^{-7}\ \text{m} = 4.00 \times 10^{2}\ \text{nm}$

2. Green light passes through a double slit for which $d = 0.20$ mm and it falls on a screen 2.00 m away. The first-order image is at 0.50 cm. What is the wavelength of the light?

$\lambda = xd/L$
$= (5.0 \times 10^{-3}\ \text{m})(2.0 \times 10^{-4}\ \text{m})/(2.00\ \text{m})$
$= 5.0 \times 10^{-7}\ \text{m} = 5.0 \times 10^{2}\ \text{nm}$

3. Yellow light that has a wavelength of 6.00×10^{2} nm passes through two narrow slits that are 0.200 mm apart. An interference pattern is produced on a screen 180 cm away. What is the location of the first-order image?

$x = \lambda L/d$
$= (6.00 \times 10^{-7}\ \text{m})(1.80\ \text{m})/(2.00 \times 10^{-4}\ \text{m})$
$= 5.40 \times 10^{-3}\ \text{m} = 5.40\ \text{mm}$

4. Violet light that has a wavelength of 4.00×10^{2} nm passes through two slits that are 0.0100 cm apart. How far away must the screen be so the first-order image is at 0.300 cm?

$$L = xd/\lambda$$

$$= \frac{(3.00 \times 10^{-3}\ \text{m})(1.00 \times 10^{-4}\ \text{m})}{(4.00 \times 10^{-7}\ \text{m})}$$

$$= 0.750\ \text{m}$$

5. Two radio transmitters are 25.0 m apart and each one sends out a radio wave with a wavelength of 10.0 m. The two radio towers act exactly like a double-slit source for light. How far from the central band is the first-order image if you are 15.0 km away? (Yes, this really happens, radio stations can and do fade in and out as you cross the nodals and the anti-nodals.)

$x = \lambda L/d = (10.0\ \text{m})(15.0 \times 10^{3}\ \text{m})/(25.0\ \text{m})$
$= 6.00 \times 10^{3}\ \text{m} = 6.00\ \text{km}$

6. Monochromatic light passes through a single slit, 0.500 mm wide, and falls on a screen 1.0 m away. If the distance from the center of the pattern to the first band is 2.6 mm, what is the wavelength of the light?

$\lambda = xw/L$
$= (2.6 \times 10^{-3}\ \text{m})(5.00 \times 10^{-4}\ \text{m})/(1.0\ \text{m})$
$= 1.3 \times 10^{-6}\ \text{m}$